~~SECRET~~ CONFIDENTIAL

25X1

F I N A L R E P O R T

on

CONTRACT RD-1 DATED 3 JUNE 1948

Your File #SES 90

25X1

July 31, 1950

CONFIDENTIAL ~~SECRET~~

GENERAL DESCRIPTION

This is an experimental or laboratory model steam power plant, built to determine the general feasibility of fractional horse-power portable units for generation of electricity.

The burner is designed to use commercial or aviation gasolines, or pressure appliance fuel commonly referred to as "White gas". It is of the "instant starting" type as used on gasoline camp stoves, in which aerated or vaporized fuel, ejected under pressure from a nozzle, entrains air for combustion and forces the combustible mixture through a burner plate, above which combustion occurs.

The boiler is of the continuous coil semi-flash type, in which feed water entering at one end of the coil is progressively heated and converted into saturated steam, and this saturated steam is in turn superheated. The rate at which fuel is burned is automatically regulated as a function of steam pressure. The rate at which water is fed into the boiler is automatically regulated as a function of temperatures in the first part of the superheater section.

The engine is of the Unaflow type, two cylinder, single acting, 1-1/8" bore x 1-1/8" stroke, with automatic internal inlet valves and eccentric operated auxiliary exhaust valves. A pump unit mounted upon one end of the engine crankcase embodies two feed water pumps, one fuel pump, one hydraulic governor unit and one lubricating oil pump.

For non-condensing operation, the exhaust steam from the engine is discharged to atmosphere. For partial condensing operation the steam is discharged in a foldable air-cooled condenser which is rigged above and behind the carrying case. Condensate from this unit is returned by gravity to the water supply tank.

To furnish some self-contained method of absorbing and measuring engine output on this experimental unit, a pair of available 125 watt 110 volt 400 cycle permanent magnet alternators is combined on one shaft in unsynchronized relationship. Since these turn at 4800 r.p.m. and the normal operating speed of the engine is about 2200 r.p.m., an elementary step-up friction drive from engine crankshaft to alternator shaft is provided. This drive must be regarded solely as a temporary expedient and not suitable for continuous use. Since the alternators are not synchronized, their external output connections are brought separately to the outside of the carrying case.

CONDENSED INSTRUCTIONS

(See "KEY" for referenced numbers)

1. Preparation (from dry condition)

Remove front and back cover panels by withdrawing pins from piano hinges.

Remove front and back engine enclosure panels by sliding upward and toward boiler.

Remove cover plates from fuel supply tank filler, water supply tank filler and telescoping flue.

Pull telescoping flue upward to position shown in Fig. 4.

Close fuel tank shutoff valve and water tank shutoff valves.

Fill fuel tank about 1 inch deep (1-1/2 pints) with gasoline.

Fill water supply tank to within 1/2 inch of top. (1-1/2 gallons)

Unscrew crankcase dipstick and breather (7); fill crankcase with S.A.E. 20 lubricating oil to oil level line on oil level sight glass (6).

For condensing operation, mount exhaust steam lines, exhaust steam riser, air condensers and water return line as shown in Figures 4, 6, and 7.

For non-condensing operation, mount exhaust steam riser with the forked discharge tubes pointing down and rearward.

Open water shutoff valve (43), open main pump vent screw (45), and auxiliary pump vent screw (49) one turn, until all air is purged from lines to pumps.

Turn "Run-Bypass" valve into "Bypass" position.

Pull hand water pump (67) outward at an angle of 15 degrees, as shown in Fig. 4, operate hand water pump full stroke until water flows from upper end of exhaust steam riser (about 75 full strokes are usually required).

SECRET

Open fuel shutoff valve (12) about 1/2 turn.

Open fuel pump vent screw (34) about one turn until air is purged from fuel lines. (When starting from a dry condition the primary fuel filter (13) may air-lock; this is remedied by slipping the neoprene hose from the lower end of this filter until fuel flows freely without entrained air).

Open hand fuel pump shutoff valve 30, 1/2 turn.

Close main burner valve (clockwise).

Pull hand fuel pump outward about 20° (Fig. 4). Operate hand fuel pump full stroke pumping both fuel and air until fuel pressure gauge reads 27 to 30 psi.

Slip starting knob onto end of generator shaft. Turn knob clockwise until auxiliary exhaust valve on back of engine shows maximum tappet clearance (about 3/32 inch). Move front end of compression release lever to right until boss on back end of this lever enters between lifter and stem of auxiliary exhaust valve on back of engine. Turn starting knob clockwise until maximum tappet clearance is obtained on auxiliary exhaust valve on front of engine; move compression release lever further to the right until the boss near the front end enters between lifter and valve stem of the auxiliary exhaust valve on front of engine, as shown in Fig. 8. Turn engine over a couple of revolutions to be sure that the bosses on the compression release lever effectively lift both auxiliary exhaust valves.

Plug in battery leads. With screwdriver or coin, bridge across control thermostat contacts (72)(left hand pair); green control indicator lamp (73), should light.

Bridge warning thermostat contacts (74) (center pair); amber warning indicator lamp (75) should light.

Bridge danger thermostat contacts (76) (right hand pair); red indicator lamp (77) should light.

Bridge control thermostat contacts (72) again, making and breaking contact at about one second intervals; a faint clicking should be heard in auxiliary water pump control solenoid (51).

Set thermocouple selector switch (81) on No. 3 position.

SECRET

2. Starting

If the foregoing instructions have been properly carried out, the following list should check:

a. Water and fuel shutoff valves open one turn.

b. Water and fuel lines vented.

c. Boiler full of water.

d. Thermostat circuits and indicator lamps O.K.

e. Auxiliary water pump control solenoid operating.

f. Run-bypass valve in bypass position.

g. Compression release lever in lifting position.

h. Fuel pressure 27 to 30 psi.

With the foregoing checked, start in the following manner:

Remove firebox peephole cover.

Pull starting valve button (20) out full stroke (about 1/2 inch).

Dip lighter swab in gasoline.

Ignite swab, insert into firebox, observe to see that it continues to burn.

Open main burner valve (19) about one-half turn (counter-clockwise). (A fraction of a second after the burner valve is opened a mixture of atomized fuel and air should emerge from the vaporizer nozzle with a distinct hissing sound; within three seconds a combustible mixture rising through the burner plate into the firebox should be ignited by the swab. The mixture should burn with a greenish or bluish clean flame close to the burner plate).

After about fifteen seconds of burner operation, or when the fuel pressure drops to about 10 psi, close the starting valve by pushing it inward against the instrument panel. Observe the condition of the flame; if it remains blue or blue green, no special attention is required. If it changes to green with

a high yellow fringe, close the main burner valve for two or three seconds and open it for one-half second a few times until the flame burns blue-green or blue without dense yellow fringe, then leave the burner valve one-half turn open. Pump fuel and air with hand fuel pump as required to maintain fuel pressure of 7 to 10 psi.

After 30 seconds to one minute of full burner operation, water and steam will begin to issue from the exhaust steam riser, and the temperature at TC3 will begin to rise. When TC3 reaches 250 to 300 deg. F., the engine should be started in the following manner:

Turn the "Run-Bypass" valve counter-clockwise about four turns in the "Run" direction; flow of live steam from the exhaust riser should then cease, and the engine pressure gauge should show the same pressure as the boiler pressure gauge. As soon as the "Run-bypass" valve is in the "Run" position, turn the engine over several times by spinning the starting knob clockwise to remove water from the lines, steam chest and cylinders.

Continue turning the starting knob with vigorous intermittent spins, and watch the engine pressure gauge. At engine pressures of 100 to 125 psi the engine should continue to turn under its own power. If pressures exceed 150 psi. it will be found difficult to spin the engine with the knob, and the run-bypass valve should be opened slightly to reduce pressure.

As soon as the engine is turning steadily, the run-bypass valve should be opened into the run position, and the compression release lever should be swung to the left as far as it will go.

From a cold start with the boiler full of water, the lighting of the fire, building up of steam and starting of the engine will ordinarily take 1-1/2 to 2 minutes; the reserve of water in the boiler is usually sufficient to carry through this starting period without necessity for hand pumping. If there have been delays in starting the engine, however, or if too much water and steam have been bypassed, the boiler may require water. This is indicated by closing of the control thermostat contacts and illumination of the green indicator lamp. If the engine is not yet running, or only running slowly, water should be pumped by hand until the green light turns off.

With the engine started and running freely under no-load, the engine driven pumps should take over all pumping requirements. The main water pump gauge should "kick" through a range of about 100 to 125 psi continuously; the auxiliary water pump gauge should similarly swing through a range of 75 to 100 psi whenever the control thermostat contacts make and the green indicator lamp lights.

The engine driven fuel pump should gradually build up the fuel pressure to 12 to 15 psi.

After a couple of minutes of no-load engine operation, temperature TC3 should stabilize at about 700 deg. F. and the fuel modulating valve should restrict the flow of fuel to the burner in such a manner as to keep the boiler pressure at about 200 psi.

3. Operation under Load.

After conditions have stabilized as described above, loads of 125 watts may be plugged into each of the outlets on the left end of the carrying case.

When under load, the engine requires more steam and in consequence more fuel must be burned and more water must be pumped.

To increase fuel rate, if necessary to maintain proper voltage under the applied load, turn the adjusting screw on the top of the fuel modulating valve (21) in a clockwise direction about 1/2 of a turn in increments of 1/6 turn. This increases fuel flow and boiler pressure, but the modulating valve continues to automatically modulate and control in the higher pressure range.

Increased water requirements are automatically satisfied by the water control system. Increase of temperature causes the control thermostat contacts to make and energize the auxiliary water pump solenoid; the auxiliary waterpump in turn supplies required water. A minute portion of the water thus supplied is diverted through the flow divider to the inlet of the thermostat, where it quickly reduces the temperature, causing the control contacts to break and de-energizing the solenoid. In normal operation the auxiliary water pump is thus turned on and off several times a minute; under greater loads the percentage of "on" time increases.

Temperatures TC3, with the selector switch in position 3, will normally range from about 700 deg. F. under no load to 800 deg. F. under full load.

4. Observation of Operation.

In normal operation the unit will automatically control itself as described above, and require no adjustments. It is an experimental model, however, with the usual susceptibility to minor operating difficulties, and should be kept under reasonable observation. The following procedure is suggested:

A. Place the selector switch on position 4; this connects thermocouple TC4 to the meter, and indicates temperatures in the central portion of the evaporator section. Normal temperature here is 300 to 350 deg. F.

B. Main water pump gauge. Should "kick" through 100-125 psi. range; reduced swing indicates deficient pump performance.

C. Auxiliary water pump gauge. Should "kick" through 75-100 psi. range whenever green light is on. Reduced swing indicates deficient pump performance; little or no swing indicates control solenoid or circuit failure.

D. Fuel pressure gauge. Should hold between 12 and 15 psi. Gradual falling off of pressure indicates pump failure or vapor locking.

E. Temperature gauge. On position 4, should hold between 300-350 deg. F. Increase above 350 deg. F. indicates deficient water supply; increase to 600 deg. F. indicates serious deficiency; increase to 750 deg. F. is signal to close main burner valve at once.

F. Indicator lamps. Intermittent flashing of the green lamp indicates satisfactory performance of auxiliary water pump and controls. Lighting of amber lamp indicates probable water deficiency, which may be checked by temperature on position 4. Lighting of red lamp is almost certain indication of water deficiency, and is a signal to close main burner valve at once.

F. Burner. Under normal operation, the fuel vapor and air mixture will pass through the induction tube and burner plate and burn above the latter with a clean blue flame, which will vary in height in response to the control imposed by the fuel modulating valve. If the temperatures in the evaporator

section increase seriously however, the flame may "pop back" through the burner plate, particularly at low fuel rates, and burn in the induction tube with a roaring sound. If this occurs, the main burner valve should be shut off and the inlet to the induction tube observed to ascertain that there is no flame at the end of the vaporizer nozzle. The burner may then be relighted with the swab while the system is still warm without use of the starting valve (20). Relighting should not be done, however, unless evaporator temperatures (position 4) are below 500 deg. F.

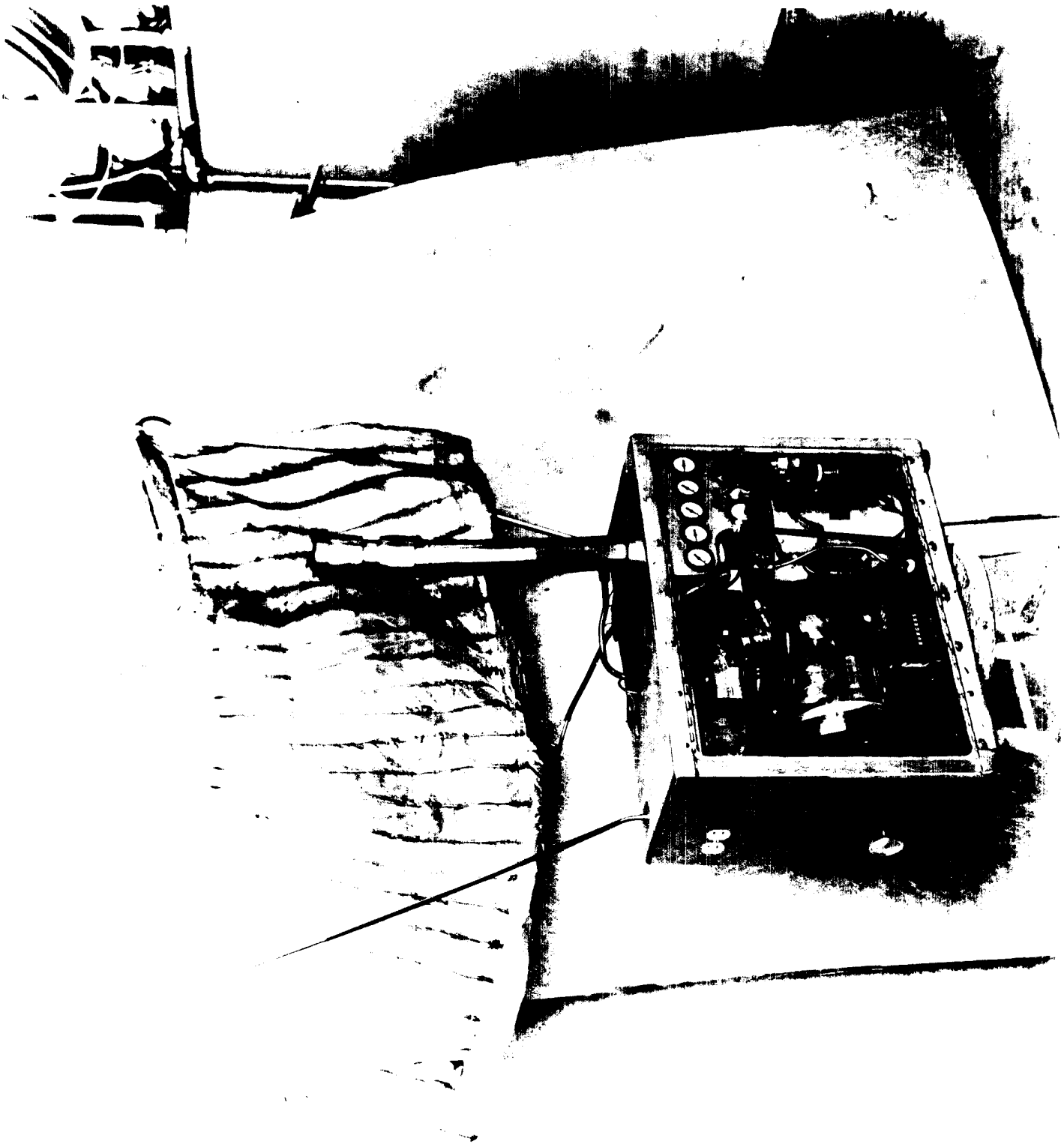
Next 2 Page(s) In Document Denied

FIG. 4

FIG. 4

Sanitized Copy Approved for Release 2011/09/20 : CIA-RDP78-03424A002400100002-4

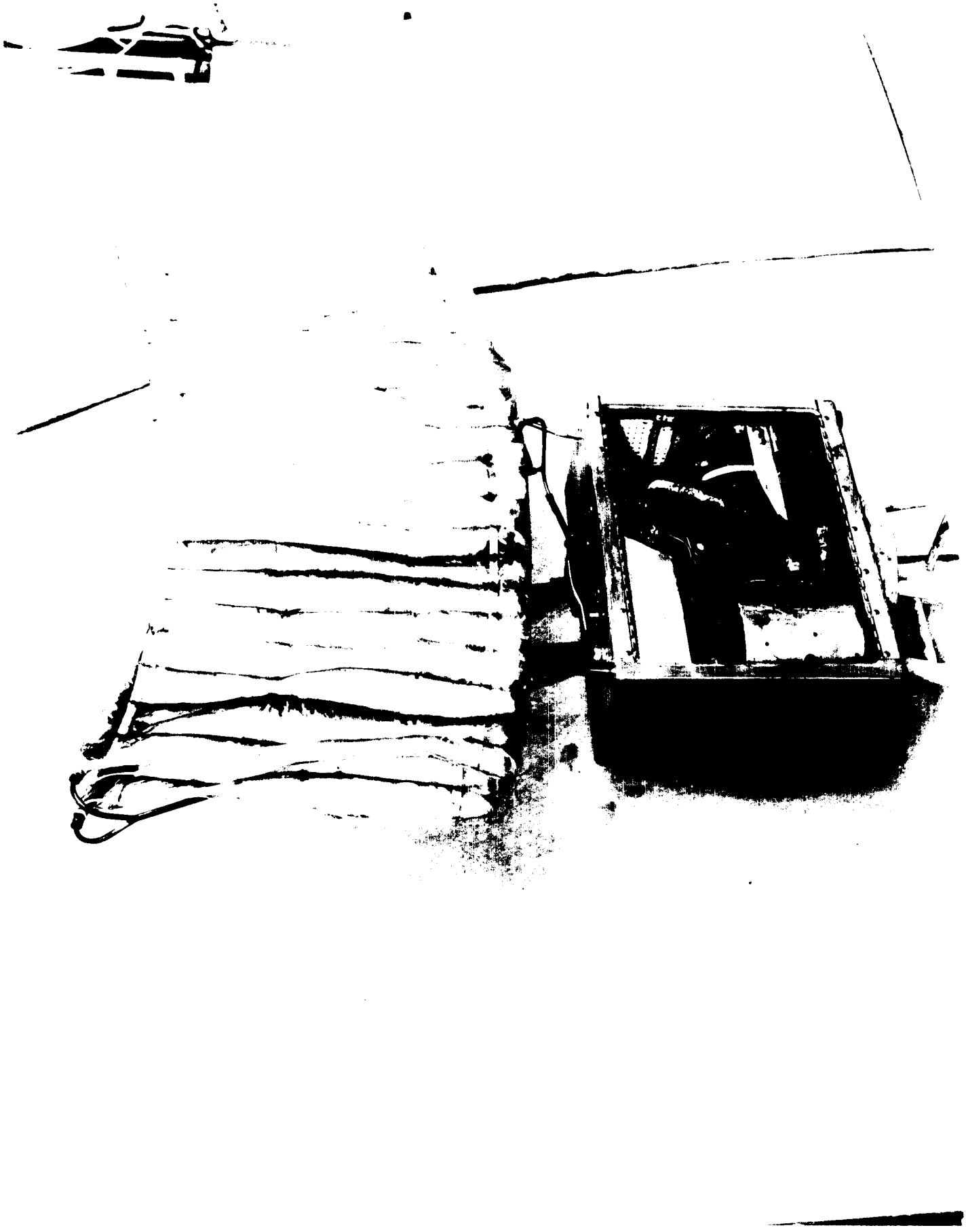
FIG. 5



Sanitized Copy Approved for Release 2011/09/20 : CIA-RDP78-03424A002400100002-4

FIG. 5

FIG. 6



Sanitized Copy Approved for Release 2011/09/20 : CIA-RDP78-03424A002400100002-4

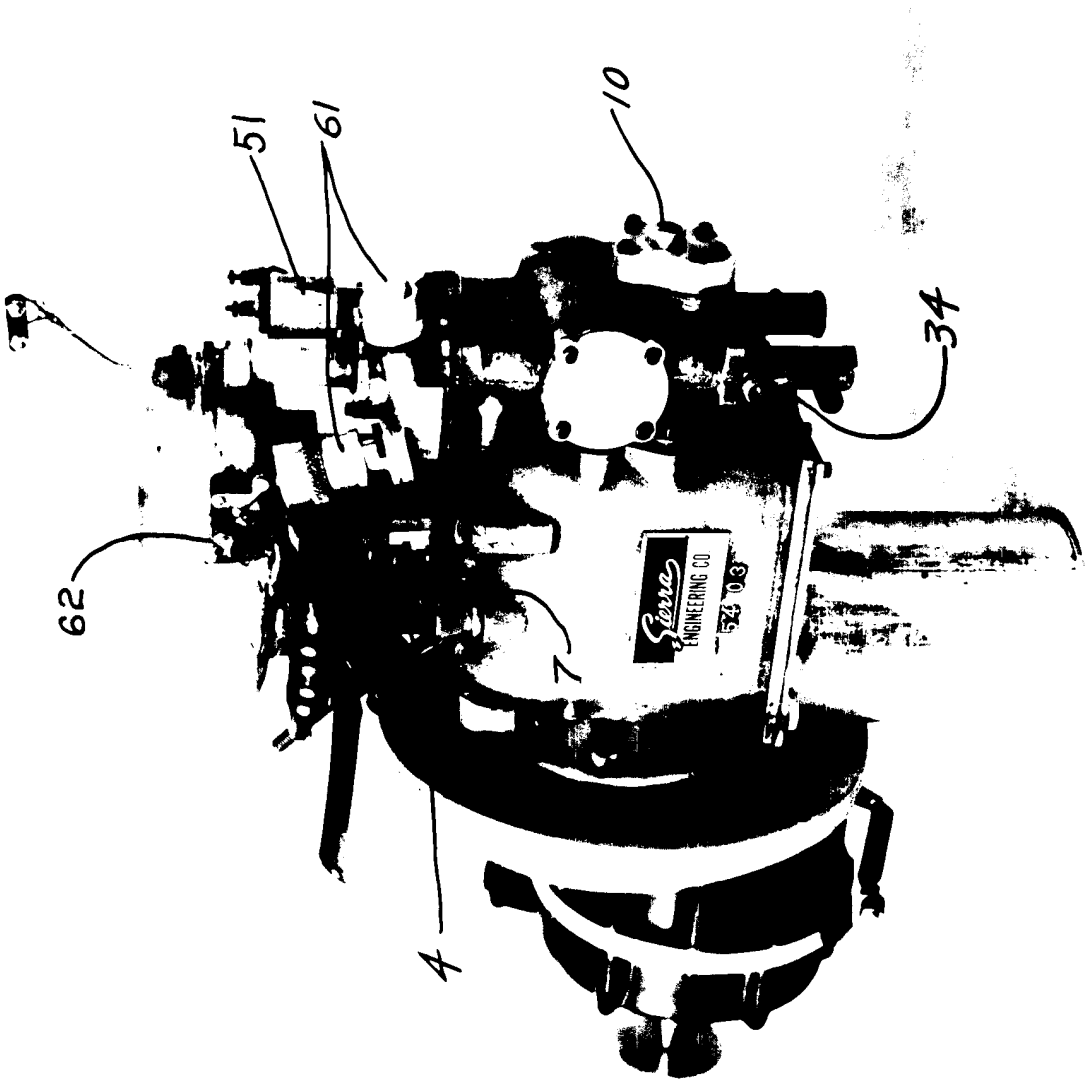
FIG. 6

FIG. 7

FIG. 7

Sanitized Copy Approved for Release 2011/09/20 : CIA-RDP78-03424A002400100002-4

Fig 8



Sanitized Copy Approved for Release 2011/09/20 : CIA-RDP78-03424A002400100002-4

Fig. 8

FIG. 9

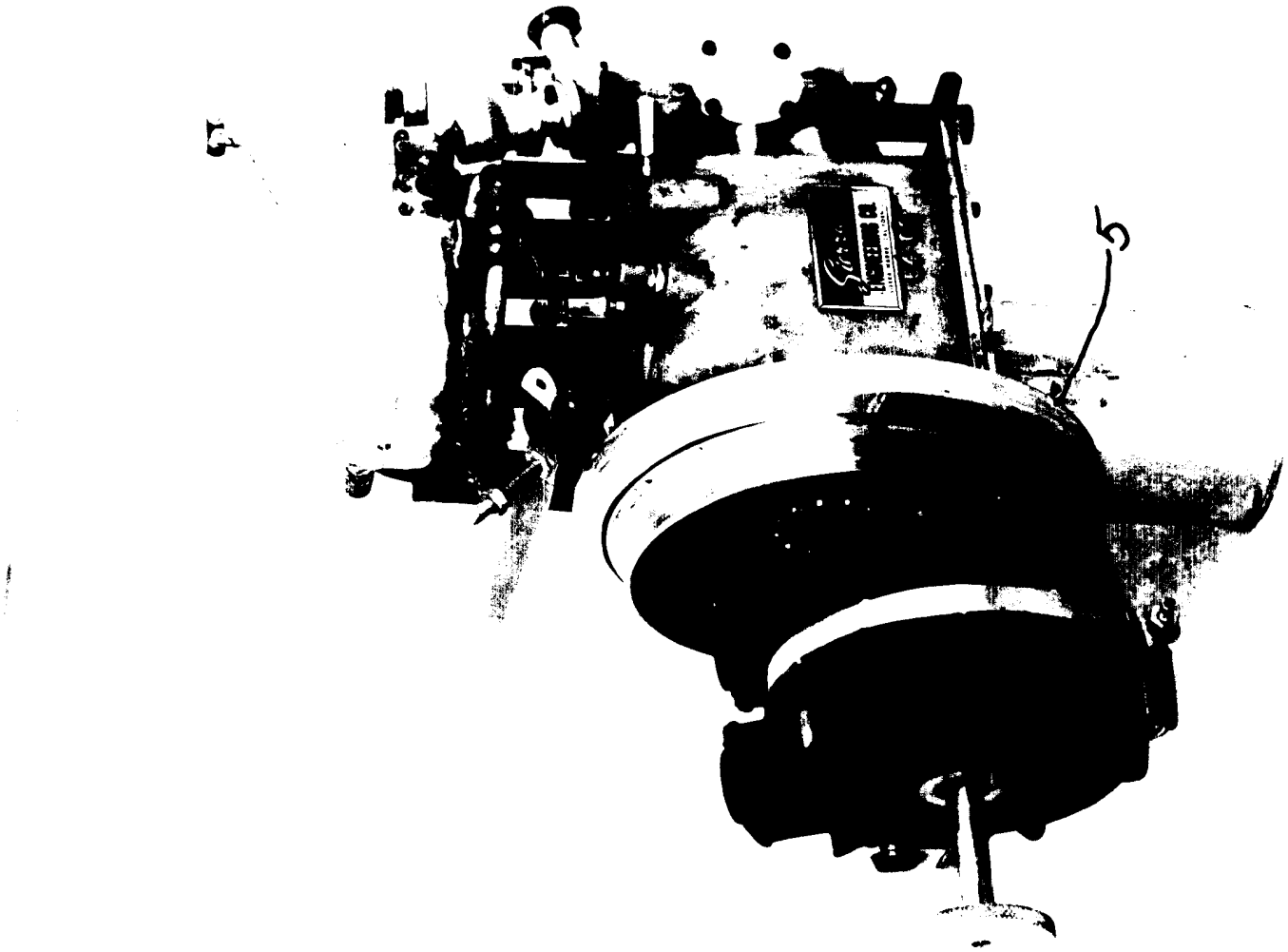
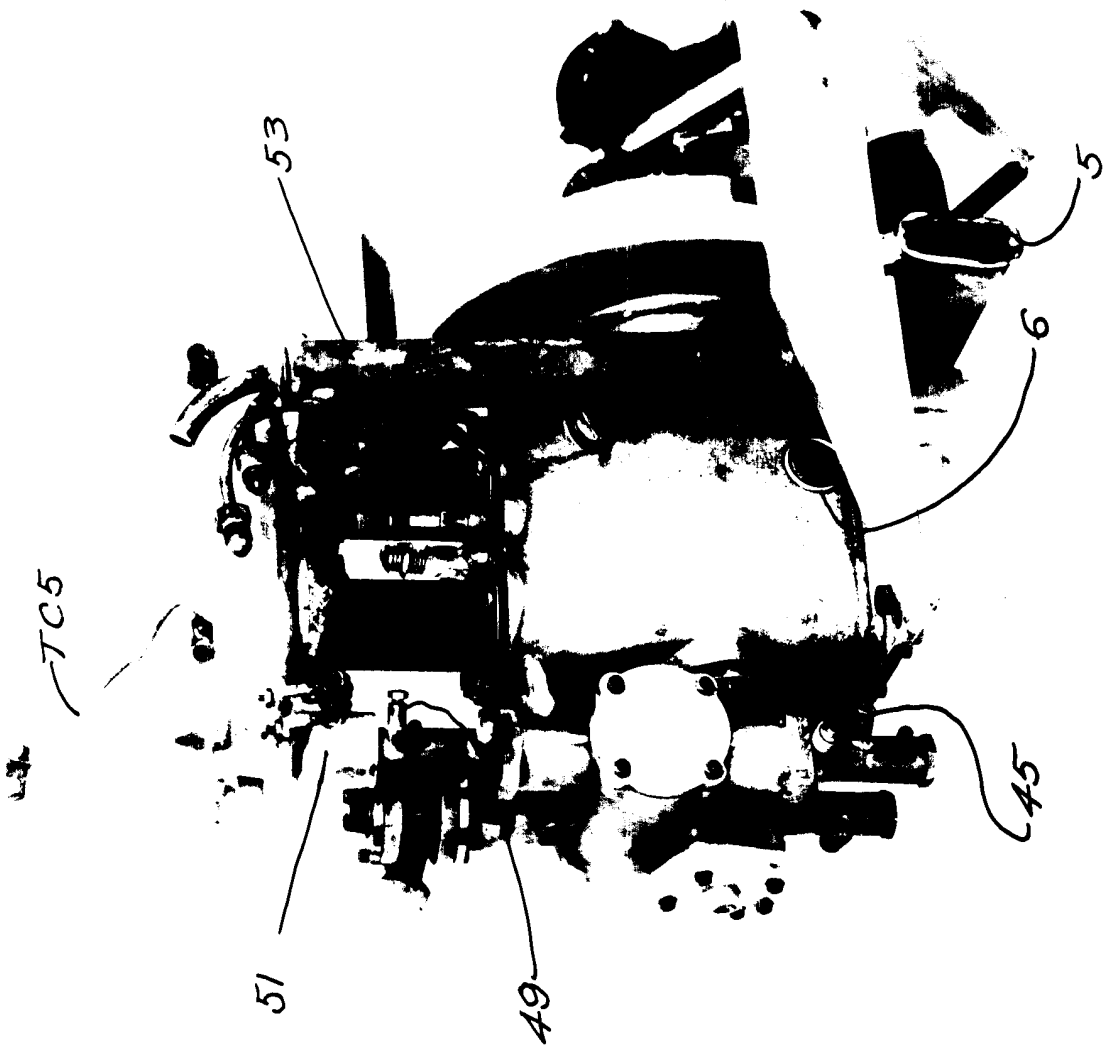


FIG. 9

Sanitized Copy Approved for Release 2011/09/20 : CIA-RDP78-03424A002400100002-4



Sanitized Copy Approved for Release 2011/09/20 : CIA-RDP78-03424A002400100002-4

FIG. 10

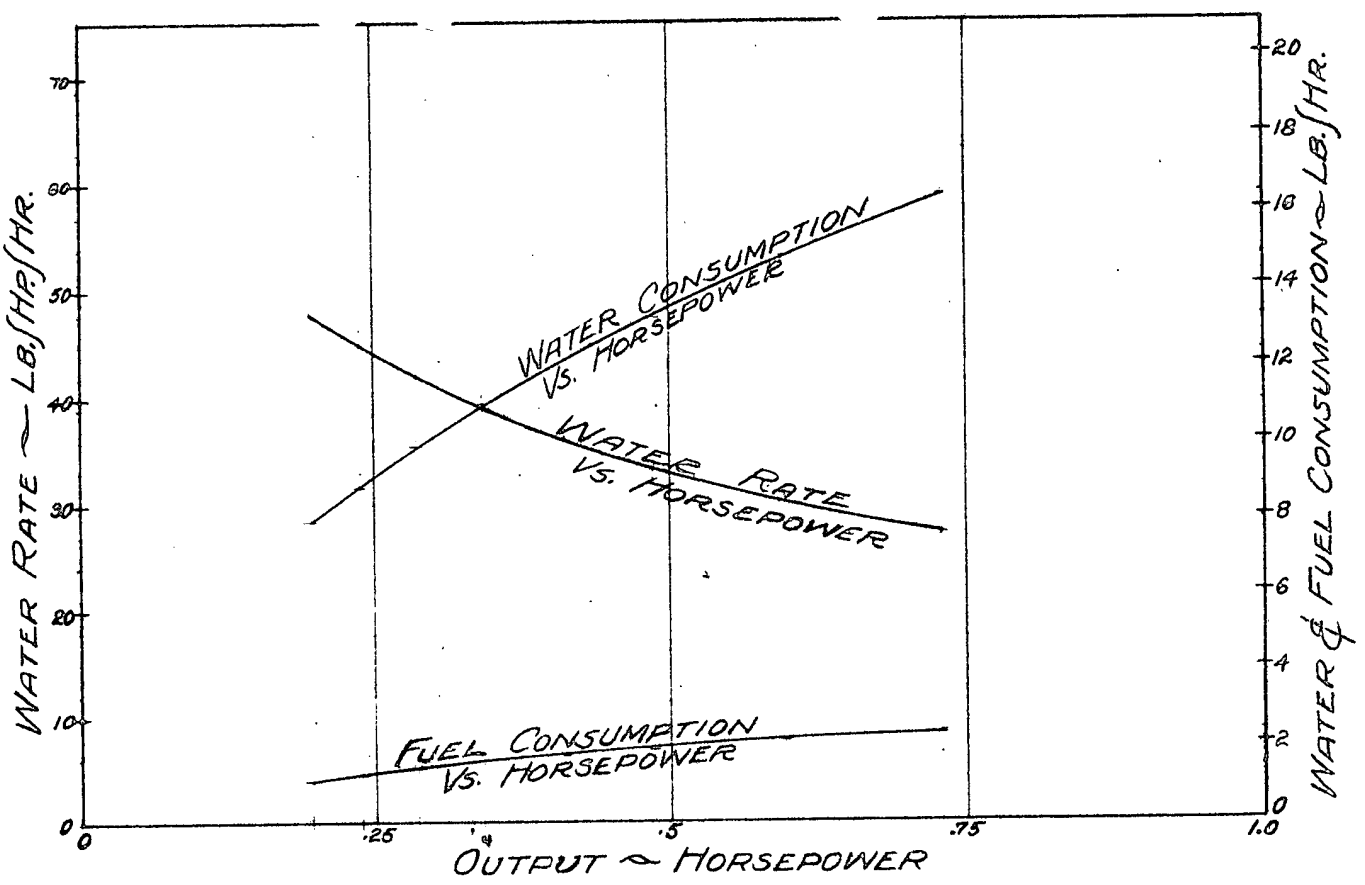
Fig. 11

Fig. 11

FIG. 12

FIG. 12

Sanitized Copy Approved for Release 2011/09/20 : CIA-RDP78-03424A002400100002-4

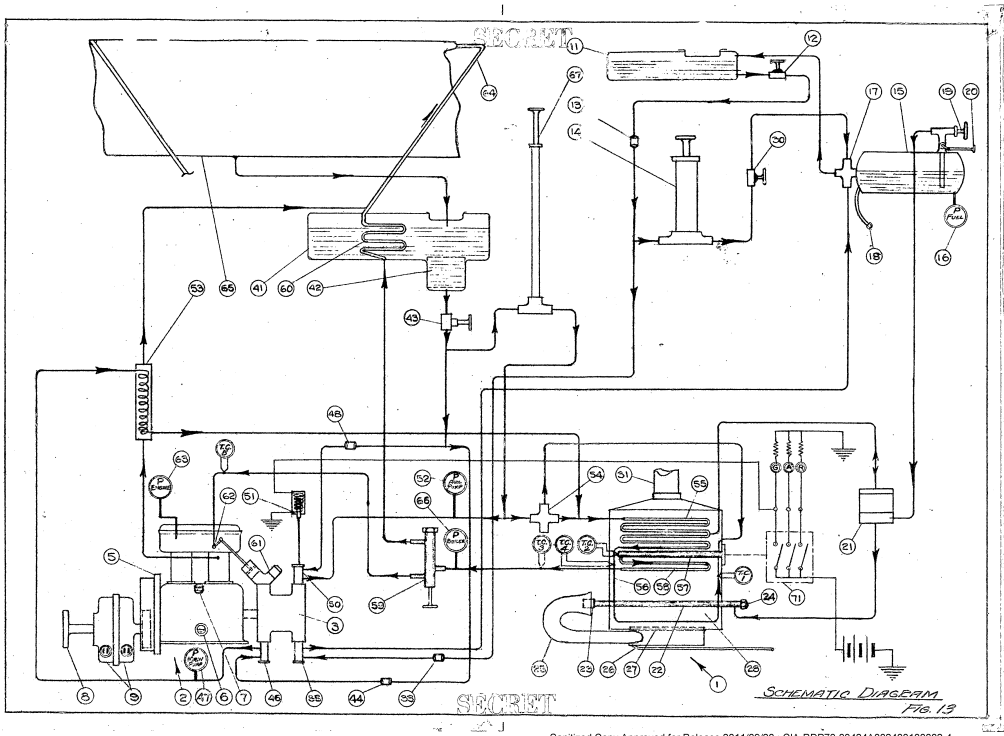


TEST PERFORMANCE

The performance curves plotted above are based upon averages of about a dozen test runs, each of 15 to 30 minutes duration.

Individual test runs gave values of water consumption, fuel consumption and water rate varying as much as plus or minus 10% from the average, depending upon combustion efficiency, steam temperature and pressure, valve timing, condition of piston rings, lubrication, jacketing, etc.

The "Water-Consumption vs. Horsepower" curve shows the net amount of water collected and condensed from the exhaust with a water cooled test condenser. The actual amount of water pumped into the boiler, evaporated and delivered as steam may be 5% to 10% greater; this difference appears as leakage past valve packings and blow-by past piston rings.



SCHEMATIC DIAGRAM
FIG. 13

SECRET

KEY

(Numbers apply generally to schematic diagram and photographs)

1 Boiler and burner assembly
2 Engine and generator assembly
3 "H" pump unit
4 Compression release lever
5 Ventilating blower
6 Oil level sight glass
7 Oil dip stick and breather
8 Starting knob
9 Alternators
10 Lubricating oil pump
11 Fuel supply tank
12 Fuel tank shut-off valve
13 Primary fuel filter
14 Hand fuel pump
15 Fuel pressure tank
16 Fuel pressure gauge
17 Fuel relief valve
18 Fuel pressure tank drain
19 Main burner valve
20 Burner starting valve
21 Fuel modulating valve
22 Vaporizer
23 Vaporizer nozzle
24 Vaporizer cleaning screw
25 Fuel induction tube
26 Induction tube drain
27 Burner plate
28 Firebox
29 Firebox peep hole
30 Hand fuel pump shutoff valve
31 Telescoping flue
32
33 Engine driven fuel pump filter
34 Engine driven fuel pump vent
35 Engine driven fuel pump
36
37
38
39
40
41 Water supply tank
42 Water treating cartridge
43 Water tank shutoff valve
44 Main water pump filter
45 Main water pump vent
46 Main water pump
47 Main water pump pressure gauge
48 Auxiliary water pump filter
49 Auxiliary water pump vent
50 Auxiliary water pump
51 Auxiliary water pump control solenoid
52 Auxiliary water pump pressure gauge
53 Exhaust to feed-water heat exchanger
54 Flow divider
55 Water heating coils
56 Evaporator coils
57 Thermostat
58 Superheater coils
59 Threeway "RUN-BYPASS" valve
60 Bypass steam cooling coil
61 Hydraulic governor
62 Governor throttle valve
63 Engine pressure gauge
64 Exhaust steam riser
65 Air cooled steam condenser
66 Boiler pressure gauge
67 Hand water pump
68
69
70
71 Thermostat contact box
72 Control thermostat contact
73 Control indicator lamp, GREEN
74 Warning thermostat contact
75 Warning indicator lamp, AMBER
76 Danger thermostat contact
77 Danger indicator lamp, RED
78 Indicator lamp resistors
79
80
81 Thermocouple selector switch
82 Thermocouple temperature gauge

TC 1 Thermocouple, inlet to thermostat
TC 2 Thermocouple, outlet from thermostat
TC 3 Thermocouple, steam out from boiler
TC 4 Thermocouple, evaporator section: 750 Deg. F DANGER
TC 5 Thermocouple, steam into engine

SECRET

INFORMATION REQUESTED IN ITEMS C AND D OF SUPPLEMENTAL AGREEMENT #2

4. We are listing below characteristics of a 40 watt unit semi-automatic operation. Our estimates are conservative and it is quite probable that they can be improved.

Size	8" x 16" x 24" Max.
Weight - Direct Connected Gen.	Under 35 lbs.
Water Consumption - Non-condensible	7# per hour - max.
Fuel Consumption	1# per hour - max.

5. Listed below are cost estimates for production units.

Estimated Unit Cost - 100 units at 100 watts -	$500.00
Estimated Unit Cost - 100 units at 40 watts	400.00

These prices do not include production design and construction of the prototype models.